

In re patent application of: Rainer Oehl, Roland Wilmer,  
Markus Berger and Klaus Binder

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P.O. Box 1450  
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Full name of the translator: Walter Ottesen

Date: 12/21/04

Signature of the translator: 

Post Office Address: P.O. Box 4026  
Gaithersburg, Maryland 20885-4026

11/20/04

Arrangement and Method for the Continuous Production of  
Tube-Shaped Structures Reinforced  
with Strengthening Support

5           The invention relates to an arrangement for the continuous production of reinforced, tube-shaped structures having:

          a conveyor apparatus for continuously driving a row of sequential cylindrical mandrels in a conveying direction and for guiding back individual mandrels to the manufacturing start with  
10       the mandrels being coupled to each other;

          at least one extrusion unit for applying a rubber or plastic layer to the periphery of the mandrels;

          at least one unit for applying at least one reinforcement layer;

15           a separation device for cutting the reinforced tube-shaped structures at the connecting locations of mutually adjoining mandrels; and,

          a stripping apparatus for stripping off the cut reinforced, tube-shaped structures from the individual mandrels.

20           The invention relates further to a method for continuously making reinforced, tube-shaped structures.

          Reinforced tube-shaped structures are especially used as rolling-lobe resilient members for air springs in motor vehicles. A rolling-lobe flexible member blank is made of rubber layers and  
25       reinforcement layers which are tube-shaped and layered one atop the other.

          Conventionally, the rolling-lobe resilient member blanks are made in that cut-out rubber plates and fabric strips are laid one atop the other and are further processed. This is relatively  
30       complex and subject to faults.

In EP 0 285 726 B1, a method for applying a filament or cord layer at defined cord angles to a rubber layer is described with the rubber layer being extruded onto a mandrel. For this purpose, the mandrel with the rubber layer is clamped into a lathe and rotated while a cord let-off ring surrounds the mandrel and is moved forward in the longitudinal direction of the mandrel with the cord let-off ring being fixed with respect to rotation.

An automated method for making multi-layered hoses or tubes is known from DE 27 50 642 C2 wherein rubber and reinforcement layers are wound on a rotating mandrel supported at a fixed location. A material feed unit is moved in the longitudinal direction along the mandrel. It is here disadvantageous that this production method is not continuous but is limited to the length of the mandrel. In addition, the thickness and the angle of the wound rubber and reinforcement layers cannot be applied with adequate accuracy needed for rolling-lobe resilient members.

A winding method for the continuous production of hoses is described in DE 1 180 513 wherein the rubber and reinforcement layers are wound on an endless row of mandrels in series one behind the other and driven in an advancing direction. The hose is vulcanized on the mandrels. Thereafter, the mandrel component pieces are pulled away and are releaseably hooked to the end of the mandrel component piece running into the winding machine. The precision, which is required for air spring resilient members, can disadvantageously not be ensured in the winding method. In addition, the mandrels are thermally loaded during vulcanization and the danger is present that the mandrels can deform so that a uniform quality of the rolling-lobe resilient member blanks can no longer be ensured.

A method and an arrangement for manufacturing curved rubber

hoses is described in DE 25 45 058 C3 wherein rubber and reinforcement layers are applied continuously on mandrels driven in a conveying direction with at least one extruder and one cord reinforcing machine. The mandrels abut directly and seamlessly one against the other. In a cutting apparatus, two mandrels are so displaced with respect to each other that a gap arises between their end faces wherein a cutting knife of the cutting apparatus can engage. Here it is disadvantageous that the filament or cord layers are stretched in the hose blank and are displaced in their positions. The mandrels are flexible and are brought into a curved position together with the hose or tubular-shaped blank piece, which is disposed on the mandrel, and are vulcanized in a vulcanization facility. The vulcanized curved hose is subsequently separated from the mandrel.

With the use of flexible mandrels, the accuracy of the rolling-lobe resilient member blanks, which is required for air springs, cannot be guaranteed. In addition, during the vulcanization of the rolling-lobe resilient member blank on the mandrel, the danger is present that the mandrel deforms. In addition, the manufacture of conical rolling-lobe resilient members is not possible.

It was therefore an object of the invention to provide an improved arrangement and a method for the continuous manufacture of reinforced hose-shaped structures which ensure an adequate manufacturing precision and high process reliability.

The object is achieved with the arrangement in that: the mandrels are rigid; the mandrels are coupled one to the other so that, in each case, a peripheral cutting zone is provided by a material different from that of the mandrel; and, that the arrangement is so aligned that the vulcanization of the

reinforced hose-shaped structure takes place only after strip off.

In contrast to the method of DE 25 45 058 C3, the extrusion of the rubber layers and the spiraling on of the cord layers for generating the reinforcement layers takes place on rigid mandrels driven continuously. A peripherally-extending cutting zone is provided of a material different to that of the mandrels between the abutting surfaces of the mutually coupled mandrels so that a cutting knife can be applied directly without the mandrels having to be shifted against each other and the layers and angles of the reinforcement layers being influenced thereby. For the reliability of the reinforced hose-shaped structures, especially for use in air springs, a defined angle of the cord layers of the reinforcement layers is decisive. The dimensional accuracy of the mandrels is not affected by the thermal process of the vulcanization because the reinforced hose-shaped structures are stripped in advance of the vulcanization from the individual mandrels. In this way, a uniform manufacturing quality is ensured.

Preferably, a separating means application device for providing separating means is provided on the periphery of the mandrels. The separating means application device is arranged ahead of the first extrusion unit as seen in the conveying direction. With the applied separating means, it is ensured that the reinforced hose-shaped structures can be easily stripped from the individual mandrels after the manufacture.

Furthermore, it is advantageous to provide a cutting device for cutting the stripped-off reinforced hose-shaped structures to defined vulcanization lengths. The cutting device is mounted in the manufacturing process ahead of the vulcanization unit.

According to the invention, the stripped-off reinforced hose-shaped structures are cut once again in advance of the vulcanization. The cutting device preferably has a cutting head drivable transversely to the longitudinal axis of the reinforced hose-shaped structures and drivable relative thereto. The cutting device also has a fixing unit for clamping and fixing the reinforced hose-shaped structures in the cutting position.

The extrusion means preferably have a gear pump for supplying the extruded rubber or plastic to an extrusion head.

In this way, a more precise control of the thickness of the rubber or plastic layers is possible.

Furthermore, a measuring device is preferably provided for continuously measuring the advancing speed of the mandrels. A control unit functions to control the quantity, which is supplied for the application of at least one rubber or plastic layer, and to control the rotational speed of the at least one bobbin creel unit in dependence upon the advancing speed in such a manner that a constant thickness of at least the first rubber or plastic layer and a defined angle of the at least one cord layer is formed.

Furthermore, preferably a measuring device is provided for continuously measuring the thickness of the first rubber or plastic layer applied directly to the mandrels and a control unit is provided for controlling the rotational speed of the downstream bobbin creels in dependence upon the measured thickness of the first rubber or plastic layer. The first extrusion unit thereby forms a control loop together with the downstream bobbin creel so that a constant cord angle is ensured in dependence upon the applied thickness of the rubber or plastic layer.

Furthermore, preferably process variable measurement means are provided for measuring the process variables when applying the rubber or plastic layers and reinforcement layers. A fault marking unit functions to apply markings to the reinforced hose-shaped structures when the measured process variables exceed or drop below a particular fault tolerance amount. In this way, it can be ensured that defective regions are separated out during the uninterrupted continuous manufacture.

The mandrels preferably have a length in the range of one to eight meters and especially preferable is the length of two to four meters.

Mandrel adapters are provided in order to be able to adapt the length of the mandrels flexibly to the production requirements. These mandrel adapters abut almost seamlessly against an assigned mandrel and are fixedly coupled thereto. In each case, the mandrel adapters have a coupling element for coupling the mandrel adapter to a further mandrel in such a manner that a cutting zone is provided from a material, which is different from the mandrel, between the mandrel adapter and the further mandrel.

The method of the invention for continuously manufacturing reinforced hose-shaped structures has the steps of:

(a) applying rubber or plastic layers and reinforcement layers as a composite on the periphery of a row of cylindrical, rigid mandrels, which are sequentially coupled one to the other, and are continuously driven in a conveying direction;

(b) cutting the reinforced hose-shaped structures at the connecting locations of mutually adjoining mandrels; the mandrels are so coupled to each other that, in each case, a

peripheral cutting zone is provided from a material, which is different from that of the mandrel, between the mandrels which abut one another at abutting surfaces;

(c) separating the mutually coupled mandrels from each other;

(d) stripping the reinforced hose-shaped structures from the mandrels;

(e) returning the mandrels for forming the row of mandrels in step (a);

(f) vulcanizing the stripped-off reinforced hose-shaped structures or parts thereof.

As a difference to the continuous manufacturing method of DE 25 45 058 C3, the method of the invention is executed with rigid mandrels, which are coupled one to the other, with a peripherally-extending cutting zone from a material different to that of the mandrel so that, when separating reinforced hose-shaped structures into segments, it is no longer necessary to pull the mandrels apart. In this way, it is ensured that the position of the reinforcement layers is not changed by the separating operation.

Furthermore, the vulcanization of the reinforced hose-shaped structures after stripping off takes place so that the mandrels, which are used for making the reinforced hose-shaped structures, are not subjected to the thermal vulcanization operation.

Further advantageous embodiments of the method are described in the dependent claims.

The invention will be explained below in greater detail with respect to the attached drawing.

FIG. 1 shows a schematic block diagram of a manufacturing arrangement for the continuous production of reinforced



hose-shaped structures.

FIG. 1 shows an arrangement of the invention for the continuous manufacture of reinforced hose-shaped structures 1 which are formed of several rubber or plastic layers (2a, 2b) one atop the other and reinforcement layers 3.

For this purpose, the manufacturing arrangement has a first extrusion unit 4a for applying a first rubber or plastic layer 2a to the periphery of cylindrical, rigid mandrels 5 which are continuously coupled one to the other and driven by a conveying unit 6 in a conveying direction X. The mandrels 5 are passed through the first extrusion unit 4a so that a rubber or plastic hose is made. The thickness of the first rubber layer 2a is measured by a measuring unit 7 which is mounted behind the first extrusion unit 4a viewed in the conveying direction X. The first extrusion unit 4a has a gear pump 8 between the extruder and an extrusion head in order to control the supplied rubber or plastic quantity precisely in dependence upon the thickness measured with the measuring device 7.

Thereafter, a cord or filament layer is applied at a defined filament angle with a bobbin creel unit 9 which rotates about the mandrels 5. Optionally, additional bobbin creel units 9 can be provided which can, for example, rotate in mutual opposition in order to apply at least one additional filament layer, which can be counter-running, as may be required.

At least one further extrusion unit 4b is provided in order to apply a further rubber or plastic layer 2b.

The advancing speed of the mandrels 5 is continuously measured by a measuring unit 10. The process variables are supplied to a control unit (open loop and closed loop) 11 and the extrusion units (4a, 4b) and the at least one bobbin creel unit 9

are so open loop controlled and so closed loop controlled in dependence upon the speed of advancement and at least the thickness of the first rubber or plastic layer 2a that a defined reinforcement layer 3 is ensured at fixed filament angles and a constant thickness of the rubber or plastic layers 2 is ensured. Especially the first extrusion unit 4a and the directly following bobbin creel unit 9 form a closed control loop because the filament angles of the filament layer, which is applied to the first rubber or plastic layer 2a, is dependent upon the thickness of the first rubber or plastic layer 2a. The filament angles and the thickness of the first rubber or plastic layer define essential quality features of reinforced hose-shaped structures, especially for use in air springs.

Process variables (such as angles and quality of filament layers) for the reinforcement layers 3 as well as the quality and thicknesses of the rubber or plastic layers 2 are measured with suitable measuring means. Defective areas are identified with a fault marking unit 12 by applying markings to the reinforced hose-shaped structures 1 when the measured process variables exceed or drop below a particular fault tolerance amount.

Furthermore, a cutting device 13 is provided for cutting the reinforced hose-shaped structures 1 at the connecting locations of mutually adjoining mandrels 5. For this purpose, the cutting device 13 or the overall system has either suitable means for detecting the peripherally-extending cut zones S between mandrels 5, which are one behind the other, or the cutting zones S are determined from the advancement speed. The cutting device 13 can, for example, have a separating knife extending about the periphery of the reinforced hose-shaped structures 1.

Thereafter, the mandrels 5 are decoupled from each other and

the cut reinforced hose-shaped structures 1 are stripped off or pulled off the particular mandrel 5 with a strip-off device 14. This takes place preferably by introducing compressed air into the intermediate space between the peripheral surface of the  
5 mandrel 5 and the inner surface of the reinforced hose-shaped structure 1. A compressed air wave first migrates from the forward end of the reinforced hose-shaped structure 1 to the rear end and the mandrel 5 is pressed out by the pressurized air acting on the end face of the mandrel. The mandrels 5 are  
10 preferably closed at the end faces.

The individual mandrels 5 are then returned by the conveying apparatus to the start of the manufacturing arrangement as sketched by the arrows. In this way, a continuous endless manufacturing process is ensured.

15 The stripped-off reinforced hose-shaped structures 1 are thereafter supplied to a cutting device 15 and cut to the defined vulcanization lengths. Viewed in the manufacturing direction, the cutting device 15 is ahead of a downstream vulcanization unit (not shown) for vulcanizing the cut sections of the reinforced  
20 hose-shaped structures. The cutting device 15 has a cutting head 16 moveable transversely to the longitudinal axis.

Preferably, a separating means application device 17 is provided for applying separating means to the periphery of the mandrels 5. The separating means application unit 17, viewed in  
25 the conveying direction X, is mounted ahead of the first extrusion unit 4a. With the applied separating means, it is ensured that the reinforced hose-shaped structures 1 can be easily stripped off the individual mandrels 5 after manufacture.